7. TROPICAL CYCLONE SUPPORT SUMMARY

7.1 TROPICAL CYCLONE FORECASTER'S REFERENCE GUIDE

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Development of a Tropical Cyclone Forecaster's Reference Guide continues. The guide consists of seven chapters. They are: 1) Tropical Cyclone Warning Support, 2) Tropical Climatology, 3) Tropical Cyclone Formation, 4) Tropical Cyclone Motion, 5) Forecast Aids, 6) Tropical Cyclone Intensity, and (7)Tropical Cyclone Structure. The first three chapters have been published as Technical Notes (available from Naval Research Laboratory (NRL)). The other four chapters are in preparation. The chapter-by-chapter publishing format not only makes the edition and inclusion of updated information easy, but also provides tropical meteorology training notes for aerographers. After all of the chapters are complete, they will be transferred to an interactive video disk format, saving considerable storage space which is especially important for shipboard use.

7.2 AUTOMATED TROPICAL CYCLONE FORECASTING SYSTEM (ATCF) UPGRADE

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The ATCF has been used operationally at JTWC since 1988. The current system runs on an IBM-DOS operating system. NRL, Monterey is adapting the ATCF to the UNIX operating system under the program direction of the Space Warfare and Systems Command. The new ATCF will use industry standard X-Window/Motif for window management and will communicate with the Tactical Environmental Support System (TESS) 3.0. The first phase of the project is expected to be completed in the summer of 1995.

7.3 PROTOTYPE AUTOMATED TROPICAL CYCLONE HANDBOOK (PATCH)

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PATCH is an expert system designed to provide tropical cyclone forecast and training guidance for the western North Pacific Ocean to JTWC. The scope of the project has expanded to include expertise pertaining to tropical cyclone formation, motion, intensification and dissipation, and structure and structure change. The expert system is an integral part of the ATCF upgrade. Initially PATCH will be in a basic stand-alone mode. Ultimately, it will be interactive with the ATCF.

7.4 TCM-93 MINI-FIELD EXPERIMENT

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The Naval Postgraduate School (NPS) and the Office of Naval Research (ONR) Marine Meteorology Program co-sponsored a mini-field experiment near Guam during July-August 1993. The Experiment Operations Center was collocated with JTWC, which provided space, shared its meteorological data bases and facili-

tated the TCM-93 operations. JTWC TDOs participated in routine meteorological discussions.

The objectives and organization of the experiment were almost the same as a similar experiment during 1992, as described in the TCM-92 Operations Plan (Elsberry et al., 1992, NPS Technical Report). Each objective involves understanding of the role of long-lived tropical Mesoscale Convective Systems (MCS) on the motion and formation of tropical cyclones.

During the period, 21 July 1993 to 12 August 1993, USAF Reserve WC-130 aircraft and crews of the 815th Tactical Airlift Squadron, Kessler Air Force Base, Mississippi, deployed to the western North Pacific. Operating from Guam, crews flew seven missions of 7-11 hours duration into tropical cyclones and nearby MCSs to collect flight-level and dropwindsonde observations in support of the TCM-93 mini-field experiment as summarized in the NPS Technical Report (Harr et al., 1993). Some special observations were collected with the new Andersen Air Force Base WSR-88D Doppler radar. Three of the seven WC-130 missions were MCS-tropical cyclone interaction cases, and four were MCS structure, merger, or tropical cyclone genesis cases. Analyses of these data sets are in progress.

7.5 TROPICAL SYNOPTIC ANALYSIS MODERNIZATION AND IMPROVEMENT PROJECT

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An effort to improve the quality of tropical synoptic analyses and the process by which they are produced has been initiated. A pilot real-time analysis effort associated with this project was conducted in July/August 1993 in support of the ONR- and NPS-sponsored mini-field experiment TCM-93. The ultimate goal of this project is to equip the tropical analyst to produce highly efficient and interactive (man/machine) analyses of the tropical atmosphere. The two essential components to be developed as a part of this project are:

- a comprehensive knowledge base of tropical synoptic conceptual models based heavily on satellite imagery interpretation to facilitate interpretation of available conventional data; and

- sophisticated workstation-based imagery and data manipulation tools tailored to the specific needs of the tropical analyst.

Although manual analyses of tropical circulations permit subjective incorporation of satellite imagery cloud patterns, present objective analysis techniques can utilize only satellite cloud-drift winds and soundings. If an objective analysis lacks structure clearly discernible from cloud patterns, a human analyst must presently redraw all the objectively produced contours or streamlines. The key premise of this analysis modernization and improvement program is that the most efficient way to let the human mind contribute to the meteorological analysis process is by contributing to the quality control of the conventional data and, most importantly, by generating additional "synthetic" data via satellite imagery interpretation. Subsequent objective analyses of the modified conventional data augmented with the synthetic data must then necessarily, but implicitly, incorporate the input of the human analyst, without requiring time-intensive drawing of every analysis line. If desired, the analyst may further refine the analysis by adjusting some of the objectively produced analysis lines.

The synoptic analyses supporting TCM-93 are documented in some detail in the Appendix to Harr et al., 1993. A number of ideas and techniques related to the analysis modernization project were introduced or tested, such as: (i) increased temporal compositing over that used by JTWC; (ii) confirming and refining imagery interpretation techniques and conceptual mod-

els; and (iii) deriving synthetic data from the center position of moving TUTT cells.

7.6 MONSOONAL INTERACTIONS LEADING TO SUDDEN TROPICAL CYCLONE TRACK CHANGES

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Nearly every year, one or more tropical cyclones are observed to undergo a particularly severe type of track change accompanied by an enhancement or surge in the monsoon southwesterly winds in the vicinity of the tropical cyclone. This type of track change typically consists of a rapid slowing of westward movement to either quasi-stationary or tight cyclonic looping motion, followed by a strong acceleration on a substantially more northward heading. The sharp northward turn routinely approaches or exceeds 90 degrees and is rarely well-forecast by objective guidance. Recent examples include Typhoons Abe (1990), Caitlin (1991), Ted (1992), and Robyn (1993).

Through the sponsorship of ONR, an extensive study of the monsoon surge track change phenomenon has been initiated. The first stage of the research has focused on revealing the basic dynamical processes involved by integrating a barotropic model with various idealized initial conditions, and comparing the model fields and vortex tracks with NOGAPS 500 hPa analyses and JTWC official best tracks of actual monsoon surge track change cases. The results achieved thus far establish that to a first order, the track change can be characterized as a binary interaction and coalescence of: (i) a large, dispersive vortex representing a monsoon cyclone or depression; and (ii) dispersion-resistant vortex representing a tropical cyclone that is embedded in the eastern portion of the monsoon cyclone. During the coalescence, the beta-effect causes part of the monsoon cyclone energy to be radiated away, forming an elongated anticyclone approximately 1200 km to the southeast. The enhanced monsoon surge winds are associates with a confluent, high gradient region that develops between the monsoon cyclone and the anticyclone. It is the strong monsoon surge, which produces a significant southerly steering flow across the tropical cyclone center, that causes the storm to track on a more northward track after coalescence with the monsoon cyclone occurs.

A manuscript documenting the above results has been submitted to Monthly Weather Review for publication and should appear sometime in late 1994. Research on the nature of monsoon surge track changes is ongoing and will include the role of diabatic heating, and prospects for improving the forecastability of the phenomenon.

7.7 HYBRID FORECAST AIDS

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Beginning in 1991, steps were undertaken to develop a set of hybrid forecast aids that would reduce the chances for very large forecast errors in difficult forecast situations. The objective was to combine the historically best-performing forecast aids together into a single aid that would have lower overall errors than any of its components. JTWC forecasters wanted to see if a consensus approach to tropical cyclone forecasts would significantly improve the quality of its warnings.

In the first version of this effort , two hybrids named BLND "blended" and WGTD "weighted" were created based on the long-term performance of nine standard forecast aids downloaded from FLENUMETOCCEN. These aids required the TDO to manually enter each of the component aids into a computer to derive the hybrid output. Subsequent analysis of these hybrids revealed that BLND and WGTD did, in fact, have the lowest overall errors of any of

JTWC's forecast aids, but that 1) too much of an emphasis was being placed on climatological aids relative to the dynamic forecast aids; 2) the need to manually enter data was too time-consuming; 3) they lacked a suitable error-checking routine; and 4) a simple average of the best-performing guidance yielded nearly the same performance as more complicated, statistically-based weighting functions.

Since 1992, the following modifications have been made to the original set of hybrid forecast aids to rectify the deficiencies described in the preceding paragraph:

1) Four climatological aids have been deleted from the BLND and two from the WGTD hybrids, and a new hybrid based exclusively on dynamic forecast aids called DAVE, or "dynamic average" has been created.

2) The hybrid calculations have been automated as a batch file which runs on the ATCF terminals and inserts the hybrid forecasts in the aids file after performing an error-checking routine.

3) The hybrids have been simplified; for the western North Pacific basin, BLND is the smple average of JTWC's six primary forecast aids - OTCM, CSUM, FBAM, JT92, CLIP and HPAC; WGTD is a weighted average of FLENUMETOCCEN forecast guidance - OTCM (29%), CSUM (22%), FBAM (14%), JT92 (14%), HPAC (14%), CLIP (7%); and DAVE is a simple average of all of the dynamic forecast aids and extrapolated forecasts from numerical models - NOGAPS (NGPS), Bracknell (EGRR), Japanese Typhoon Model(JTYM), JT92, FBAM, OTCM and CSUM.

4) BLND and WGTD hybrid forecast algorithms have also been developed for the North Indian Ocean and the Southern Hemisphere based on the historical performance of FLENUMETOCCEN forecast aids in each of these tropical cyclone regions.

The performance of each hybrid, and a head-to-head comparison with each of its component parts and with the official JTWC forecast against the final best tracks for the western North Pacific for 1993 are listed in Table 7-1.

Table 7-1 COMPARISON OF BLND, WGTD, AND DAVE GUIDENCE WITH THEIR COMPONENT PARTS AND WITH THE OFFICIAL JTWC FORECAST FOR THE WESTERN NORTH PACIFIC FOR 1993. Negative values indicate that the hybrid performed better than indicated component forecast aid.

	BLND	JTWC	OTCM	CSUM	FBAM	JT92	CLIP	HPAC	
24hr	119nm	(+8)	-14	-10	-20	-9	-17		
48hr	216nm	(+3)	-28	-20	-14	-8	-30	-38	
72hr	308nm	-15	-52	-36	-40	-29	-56	-56	
	WGTD	JTWC	OTCM	CSUM	FBAM	JT92	CLIP	HPAC	
24hr	116nm	(+5)	-16	-13	-5	-3	-12	-19	
48hr	215nm	(+2)	-28	-21	-14	-9	-31	-39	
72hr	308nm	-15	-52	-35	-40	-29	-55	-56	
	DAVE	JTWC	OTCM	CSUM	FBAM	JT92	NGPS	EGRR	JTYM
24hr	110nm	(+2)	-23	-19	-12	-9	-54	-40	-1
48hr	195nm	-19	-47	-41	-34	-29	-70	-34	-6
72hr	298nm	-26	-61	-47	-51	-43	-29	-16	na

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